Chapter 5

Technology for Capacity Improvement

There are many technological initiatives underway that offer significant promise to improve the capacity of an airport, its surrounding terminal airspace, and the en route airspace. Even when considered individually, these technologies are significant steps in the right direction. However, the impact of each initiative will be enhanced by an integrated approach to capacity improvement through effective coordination of the various programs. At an overall level, this integration will be accomplished through the activities of the National Simulation Capability described in Section 5.4.1.

There are many technological initiatives underway that offer significant promise to improve the capacity of an airport, its surrounding terminal airspace, and the en route airspace. The impact of each initiative will be enhanced by an integrated approach to capacity improvement through effective coordination of the various programs. This integration will be accomplished through the activities of the National Simulation Capability.

Section 5.1 covers technologies applicable to airport surface operations. Section 5.2 discusses programs that apply to the adjacent terminal airspace. These include the Precision Runway Monitor and the Converging Runway Display Aid that directly support the approach procedure improvements described in Chapter 3. Section 5.3 discusses technologies applicable to the en route airspace, including oceanic airspace. Section 5.4 covers technologies and programs that support planning and integration of the above programs, as well as technologies that will make changes and improvements to the National Airspace System easier and more efficient to implement.

Complete project details, including funding and implementation dates, where appropriate, are given in Appendix G. The projects described there include the key projects discussed in this section plus a large number of other projects that have an impact on capacity, although their primary focus might be different.

5.1 Airport Surface Capacity Technology

Nearly 80 percent of all flights are delayed 1 to 14 minutes in taxi-in and taxi-out phases of flight. Taxiway interference, separation at intersections, departure sequencing, and the like, all contribute to surface-related flight delays. The Airport Surface Traffic Automation System will provide automation that will make ground operations safer and more efficient.

The Airport Surface Traffic Automation System will provide automation that will make ground operations safer and more efficient.

5.1.1 Airport Surface Traffic Automation Program

The purpose of the Airport Surface Traffic Automation (ASTA) program is to increase aviation safety by reducing runway incursions and surface collisions in the airport movement area and to provide controllers with automated aids to reduce delays and improve the efficiency of surface movement.

The ASTA program comprises five elements: a runway status light system, a surveillance data link, aural and visual warnings, data tags, and a traffic planner. The program will develop an enhanced surface safety system using the Airport Surface Detection Equipment (ASDE-3) primary ground sensor radar, Automated Radar Terminal System (ARTS), Differential (corrected) Global Positioning System (DGPS), and Airport Movement Safety System (AMASS). ASTA will provide controllers with automatically generated alerts and cautions as well as data tags to identify all aircraft and special vehicles on the airport movement area in all-weather conditions. Future enhancements will include a traffic planner and Cockpit Display of Surface Traffic Information (CDTI). The ASTA program examines the roles and responsibilities of controllers, pilots, and ground vehicle operators when operating on the airport.

The AMASS is an automation enhancement to the ASDE-3 primary ground sensor radar that provides an initial safety capability on runways and connecting taxiways. After determining that a group of ASDE-3 radar returns make up a target, the AMASS then analyzes that target's position and motions with respect to other targets and the defined airport operational configuration to determine if there are any conflicts among targets or with defined operations. If there are conflicts, a verbal and graphical alert is given to the controllers in the tower cab. The AMASS also has an interface with the Automated Radar Terminal System (ARTS) in order to include airborne aircraft on final approach in the check for conflicting target operations on the airport surface. All airports slated to receive ASDE-3/AMASS equipment will also receive ASTA. For those airports not equipped with ASDE-3/AMASS, ASTA will use other potential ground movement sensors, such as DGSP surveillance data link to detect aircraft and vehicles.

The ASTA program will share information with the Terminal Air Traffic Control Automation (TATCA) program to create an interrelated runway incursion prevention system. When completed, the ASTA program will provide an all-weather, automated capability that allows for safe, higher capacity airport operations.

5.2 Terminal Airspace Capacity Technology

There are a number of programs that will improve the capacity of an airport's surrounding terminal airspace. The Precision Runway Monitor and the Converging Runway Display Aid have been discussed in Chapter 3 in connection with procedures for improved landing capacities at airports with multiple runways. The Microwave Landing System will make precision approach procedures available at more runways at more airports by significantly reducing the siting problems and frequency congestion associated with ILS.

The Center-TRACON Automation System will complement the above systems by aiding the controller in merging traffic as it flows into the terminal area. It will also support enhanced air traffic throughput and avoid undesirable bunching and gaps in the traffic flow on the final approach path. This system and the Converging Runway Display Aid have been combined into the Terminal ATC Automation Program. Finally, the Traffic Alert and Collision Avoidance System has the potential to expand beyond its current role of providing airborne collision avoidance as an independent system. It has the potential to reduce aircraft spacing in a variety of situations, leading to increased capacity.

The Microwave Landing System will make precision approach procedures available at more runways at more airports by significantly reducing the siting problems and frequency congestion associated with ILS.

The Center-TRACON Automation System will aid the controller in merging traffic as it flows into the terminal area.

5.2.1 Terminal ATC Automation (TATCA)

The purpose of the Terminal ATC Automation Program (TATCA) is to assist air traffic controllers and supervisors in enhancing the terminal area air traffic management process and to facilitate the early implementation of these aids at busy airports. The TATCA program consists of two projects: the Converging Runway Display Aid (CRDA) and the Center-TRACON Automation System (CTAS). Longer-term TATCA activities include the integration of terminal automation techniques with other air traffic control and cockpit automation capabilities.

5.2.1.1 Converging Runway Display Aid

The CRDA displays an aircraft at its actual location and simultaneously displays its image at another location on the controller's scope to assist the controller in assessing the relative position of aircraft that are on different approach paths. The CRDA function is now implemented in version A3.05 of the ARTS IIIA system.

Actual operations have shown that this aid is effective in increasing capacity by allowing multiple runways to be used simultaneously under IFR. At St. Louis, the FAA has conducted a demon-

Actual operations have shown that CRDA is effective in increasing capacity by allowing multiple runways to be used simultaneously under IFR.

stration of this tool to measure its effect on dependent precision converging approaches in near Category I minima. (This is discussed further in Section 3.4.2.) Results from field testing at St. Louis have shown an increase in arrival rates from 36 arrivals per hour to 48 arrivals per hour, an increase of 33 percent. National standards for CRDA were published in November 1992.

5.2.1.2 Center-TRACON Automation System

The approach to major terminal areas represents one of the most complex and high-density environments for air traffic control. Arrivals approach from as many as eight directions, with jet arrivals descending from high altitudes while other traffic enters from low altitudes. It is difficult for controllers to foresee how traffic from one approach path will ultimately interact with traffic from other approach paths. This results in traffic arriving either in bunches, which leads to higher controller workload and increased fuel burn to maintain separation, or with significant gaps, which in turn reduces airport capacity. Speed and space restrictions in the terminal area add to the difficulty of maintaining an orderly flow to the runway. Visibility and wind shifts, variations in aircraft mix, wake vortex considerations, missed approaches, runway/route changes or closings, all add to the difficulty of controlling traffic efficiently and safely in the terminal airspace.

CTAS is designed to improve system capacity by helping the controller smooth out and coordinate traffic flow efficiently, while maintaining the same level of safety present in today's system.

CTAS is designed to improve system performance (e.g., efficiency, capacity, controller workload), while maintaining at least the same level of safety present in today's system, by helping the controller smooth out and coordinate traffic flow efficiently. The earliest CTAS product is the Traffic Management Advisor (TMA), with one TMA specifically designed for the Center environment (CTMA) and one for the TRACON (TTMA). The TMA determines the optimum sequence and schedule for arrival traffic, and coordination between air traffic control facilities such as a Center and a TRACON is managed via the TMAs for the respective facility. Other CTAS products are the Final Approach Spacing Tool (FAST) for the TRACON and a Descent Advisor (DA) for the ARTCC. FAST aids TRACON controllers in merging arrival traffic into an efficient flow to the final approach path and also supports controllers in efficiently merging missed approach and pop-up traffic into the final approach stream. DA assists Center controllers in meeting precise arrival times efficiently while maintaining separation.

A CTAS functionality under concept exploration is Expedite Departure Path (EDP). EDP is intended to accurately model aircraft ascent up to cruise altitude. Ultimately this knowledge can be used in the terminal and en route environments to interleave departing aircraft into the existing flow of en route aircraft.

The field-test deployment of TMA has already begun, and a TMA is operating continuously at Denver Center. A TTMA is installed at Denver TRACON and is to undergo field development and evaluation. TTMA capability must be in place for FAST operations, and CTMA must precede DA operations. Longer-term CTAS activities focus on integration of terminal automation with other ATC automation and cockpit automation activities.

5.2.2 Precision Runway Monitor (PRM)

Significant capacity gains can be achieved at airports with closely-spaced parallel runways if the allowable runway spacing for conducting independent parallel instrument approaches can be reduced. (The benefits associated with reduced spacing are discussed in Section 3.3.2.) Current criteria allow independent approaches to parallel runways separated by 4,300 feet or more. This standard was established based in part on the surveillance update rate and accuracy of the airport surveillance radars (ASRs) and the terminal Automated Radar Terminal System (ARTS) capabilities. Analysis and demonstrations have indicated that the separation between parallel runways could be reduced if the surveillance update rate and the radar display accuracy were improved, and special software was developed to provide the monitor controller with alerts. Conventional airport surveillance radars update the target position every 4.8 seconds.

The PRMs consist of improved antenna systems that provide high azimuth and range accuracy and higher update rates, a processing system that monitors all approaches and generates controller alerts, and a high resolution display system.

The FAA has fielded engineering models of two types of PRM systems to investigate the reduction in separation associated with these improvements. The PRMs consist of improved antenna systems that provide high azimuth and range accuracy and higher update rates than the current terminal ASR, a processing system that monitors all approaches and generates controller alerts when an aircraft appears to be entering the “no transgression zone” (NTZ) between the runways, and a high resolution display system. One version uses an electronically scanned antenna that is capable of updating aircraft positions every half a second, and the other uses two mechanically rotating antennas mounted back-to-back that together update aircraft positions every 2.4 seconds.

Procedures to allow independent parallel operations for runways as close as 3,400 feet apart were published in 1991. Further research and development, including ATC simulations at the FAA Technical Center, are planned to determine the requirements for conducting independent parallel approaches to runways as close as 3,000 feet apart.

A contract was let in the spring of 1992 for procurement of five electronically scanned (E-Scan) PRM antenna systems, with delivery planned for 1994.

5.2.3 Microwave Landing System (MLS)

The Instrument Landing System (ILS) has provided dependable precision approach service for many years. However, inherent characteristics of the ILS cause difficulties in congested terminal areas. Of particular concern from an air traffic perspective is the long straight-in flight path required by ILS. Although not a major concern for isolated airports without obstruction problems, for closely spaced airports, ILS finals often create conflicts because flight paths may cross in ways that preclude separation by altitude. In these configurations the airports become interdependent (i.e., preferred operations cannot be conducted simultaneously at the affected airports), causing delays and constraining capacity. In areas such as New York, the curved approach capability provided by MLS will provide a solution to the interdependency of proximate airports.

The curved approach capability provided by MLS will provide a solution to the interdependency of proximate airports. The MLS/RNAV capability will permit the design of instrument approach procedures that more closely approximate traffic patterns used during VMC.

In general, the MLS/RNAV capability with wide-area coverage will provide more flexibility in the terminal airspace. For aircraft equipped with MLS/RNAV, it will permit the design of instrument approach procedures that more closely approximate traffic patterns used during VMC. Typically these result in shorter flight paths, segregation of aircraft by type, reduction of arrival and departure gaps, and avoidance of noise-sensitive areas.

MLS will also enable the FAA to provide precision approach capability for runways at which an ILS could not be used due to ILS localizer frequency-band congestion or FM radio transmitter interference. For example, it is already difficult to add ILS facilities in congested areas such as Chicago and New York. The MLS has two hundred operational channels, with additional channels available for future growth and development.

It may be possible to achieve lower minima with MLS than can be achieved with ILS at some sites. Moreover, MLS will relieve surface congestion resulting from restrictions caused by ILS critical area sensitivity to reflecting surfaces such as taxiing and departing aircraft.

Use of MLS back azimuth for missed approach guidance may help support development of approach procedures for converging runways and triple runway configurations. Use of back azimuth for departure guidance will help ease airspace limitations and restrictions on aircraft operations due to noise abatement requirements.

MLS computed-centerline capability will provide for more flexible ground siting of equipment to compensate for terrain irregularities that do not permit a centerline siting. Additionally, MLS does not require as extensive a site preparation as ILS glide slope, since MLS does not form guidance signals through ground reflection. MLS computed centerline will also provide the capability to compute an approach to secondary runways, both parallel and intersecting, that lie within the coverage volume of the instrumented runway.

A contract was awarded in 1992 for development of an MLS design to meet Category (CAT) II and III requirements. A production decision is expected in 1995, with deliveries in 1997.

5.2.4 Traffic Alert and Collision Avoidance System (TCAS) Applications

TCAS is an airborne system that operates independently of ground-based ATC to provide the pilot with advisories concerning nearby transponder-equipped aircraft. The TCAS II system, mandated for use in transport category aircraft, provides relative position information and, when necessary, advisories for vertical maneuvers to avoid collisions. This system is expected to be fully implemented on transport category aircraft by the end of 1993. At the current time, about 75 percent of U.S. transport aircraft are already equipped. Because of the situational information provided by TCAS and its widespread equipage, it has been identified as having the potential to increase ATC capacity and efficiency and reduce controller workload.

TCAS is an airborne system that provides the pilot with advisories concerning nearby transponder-equipped aircraft. A program is expected to begin in FY94 to investigate the use of TCAS to support reduced spacing on final approach

A program is expected to begin in FY94 to investigate the use of TCAS to extend approach procedures to lower minima, support reduced spacing on final approach, reduce the stagger requirement for dependent converging approaches using the CRDA, allow departures at reduced spacing, and monitor separation between aircraft on independent approaches. Should these applications prove successful, additional development will be pursued in the areas of TCAS-based parallel approach monitoring, TCAS-based self-spacing, and other more advanced applications.

Some conceptual definition work has been performed in the area of TCAS support for reduced spacing on final approach. The concept and a computer-based demonstration have been briefed to the FAA, the pilot and controller communities, and a symposium held at Embry-Riddle Aeronautical University.

5.2.5 Wake Vortex Avoidance/Advisory System (WVAS)

A better understanding of wake-vortex strength, duration, and movement could result in the reduction of aircraft separation criteria. Revised wake-vortex separation criteria may increase airport capacity by 12 to 15 percent in instrument meteorological conditions (IMC), thereby enhancing airspace use and decreasing delays.

Several vortex detection and measurement systems will be deployed at selected airports to monitor wake-vortex strength, transport characteristics, and decay. Wake vortex data obtained from these airports will be combined with data from tower fly-by tests already completed to provide a basis for reviewing existing separation standards and recommending modifications to those standards. The feasibility of increasing the small aircraft category weight limit from 12,000 to 19,000 pounds will be determined.

Plans include cockpit simulations to determine if separation standards for heavy aircraft operating behind heavy aircraft can be reduced from four miles in trail to three miles. This will be followed by examining the separation for large-behind-large and issues relating to closely spaced runways, departure delays, and departure sequencing which would interconnect with terminal automation.

5.3 En Route Airspace Capacity Technology

En route airspace congestion is being identified increasingly as a factor in restricting the flow of traffic at certain airports. One cause of en route airspace congestion is that ATC system users want to travel directly from one airport to another at the best altitude for their aircraft, and hundreds of aircraft have similar performance characteristics. Therefore, some portions of airspace are in very high demand, while others are used very little. This non-uniform demand for airspace translates into the need to devise equitable en route airspace management strategies for distributing the traffic when demand exceeds capacity. Initiatives designed to reduce delays, match traffic flow to demand, and increase users' freedom to fly user-preferred routes are underway.

Initiatives designed to reduce delays, match traffic flow to demand, and increase users' freedom to fly user-preferred routes are underway.

Automated En Route Air Traffic Control (AERA) is a long-term evolutionary program that will increasingly allow aircraft to fly their preferred routes safely with a minimum of air traffic control intervention. The Advanced Traffic Management System (ATMS) will allow air traffic managers to identify in advance when en route or terminal weather or other factors require intervention to expedite and balance the flow of traffic.

The need for increased efficiency in oceanic airspace is also being addressed. Initiatives that improve the control of this airspace, particularly the more accurate and frequent position reporting resulting from Automatic Dependent Surveillance (ADS) using satellite technology, will make it possible to effect significant reductions in oceanic en route spacing.

Other means of improving en route airspace capacity include reducing the vertical separation requirements at altitudes above FL290 to allow more turbojet aircraft to operate along a given route near their preferred altitudes and reducing the minimum in-trail spacing to increase the flow rate on airways.

5.3.1 Advanced Traffic Management System (ATMS)

The purpose of the ATMS is to research automation tools to minimize the effects of NAS overload on user preferences without compromising safety. This is accomplished by:

- Monitoring the demand on and capacity of ATC resources,
- Developing alternative strategies to balance demand and capacity to prevent critical entities from being overloaded,
- Coordinating and implementing strategies to assure maximum use of critical resources when a demand/capacity imbalance is predicted or detected.

Automation tools shown to be beneficial through the ATMS research and development program will be implemented and fielded for operational use in the Enhanced Traffic Management System (ETMS).

The Aircraft Situation Display (ASD) was the first capability developed by ATMS. The ASD generates a graphic display that shows current traffic and flight plans for the entire NAS. The ASD is currently deployed at the Air Traffic Control System Command Center (ATCSCC), all ARTCCs, selected TRACONs, and two Canadian locations.

The ASD has helped increase system capacity in several ways. It allows traffic management specialists to observe approaching traffic across ARTCC boundaries. This has allowed the reduction or elimination of many fixed miles-in-trail restrictions (and the resultant delay of aircraft) that were in effect prior to the deployment of ASD. It assists traffic management specialists in planning arrival flows for airports that are close to ARTCC boundaries, resulting in smoother arrival flows and better airport utilization. It allows traffic management specialists to detect and effect solutions

The purpose of the ATMS is to research automation tools to minimize the effects of NAS overload on user preferences without compromising safety.

Capabilities developed or under development by ATMS include the Aircraft Situation Display, Monitor Alert, Automated Demand Resolution, Dynamic Special Use Airspace, Strategy Evaluation, and Automated Execution.

Automation tools shown to be beneficial will be implemented and fielded for operational use in the Enhanced Traffic Management System.

to certain congestion problems, such as merging traffic flows, well in advance of problem occurrence and even before the aircraft enter the ARTCC where the congestion problem will occur. Small adjustments to traffic flows made early can avoid large delays associated with last-minute solutions.

The second capability developed by ATMS was the Monitor Alert, which predicts traffic activity several hours in advance. It compares the predicted traffic level to the threshold alert level for air traffic control sectors, fixes, and airports, and highlights predicted problems. It will aid in detecting congestion problems further in advance, enabling solutions to be implemented earlier. The Monitor Alert has recently been implemented at the ATCSCC, all ARTCCs, and several TRACONs.

Four future capabilities that are being developed through ATMS are Automated Demand Resolution, Dynamic Special Use Airspace, Strategy Evaluation, and Automated Execution. Automated Demand Resolution will examine problems predicted by Monitor Alert and suggest several alternative problem resolutions. The suggested resolutions are planned to respond to each problem without creating conflicts or additional problems. Dynamic Special Use Airspace will provide automation to allow consideration of actual and scheduled military operations in the national flow management decision making process. Strategy Evaluation will provide a tool to evaluate alternative flow management strategies. Automated Execution will generate and distribute facility and aircraft-specific directives to implement selected strategies.

In addition to domestic flow management capabilities, research is being conducted for oceanic flow management capabilities. Track Generation will define a set of tracks for a prescribed region of airspace. Track Advisory will advise oceanic traffic managers of the most efficient tracks available to individual aircraft approaching the track system. Oceanic Traffic Display will assist the oceanic traffic manager in routing aircraft. Further development will concentrate on the integration of domestic and oceanic capabilities.

5.3.2 Automated En Route Air Traffic Control (AERA)

AERA is a collection of automation capabilities that will support ATC personnel in the detection and resolution of problems along an aircraft's flight path in coordination with traffic flow management. AERA will help increase airspace capacity by improving the ATC system's ability to manage more densely populated airspace. AERA will also improve the ability of the ATC system to accommodate user preferences. When the most desirable routes are unavailable

AERA will help increase airspace capacity by improving the ATC system's ability to manage more densely populated airspace.

because of congestion or weather conditions, AERA will assist the controller in finding the open route closest to the preferred one.

Laboratory facilities for the AERA program were established in 1987. This laboratory has been used for prototyping and analyzing systems and concepts to develop operational and specification requirements, as well as supporting technical documentation. Initial algorithmic and performance specifications and trial ATC procedures were completed in 1991. These specifications were updated in 1992 to reflect the transition strategy adopted to implement AERA capabilities. This strategy will minimize disruption of on-going operations and encourage effective assimilation of AERA capabilities by the controller work force.

In subsequent phases of the program, the FAA Technical Center will evaluate software and operational procedures changes developed to implement AERA capability enhancements. The operational AERA software and ATC procedures will then be upgraded as a result of the operational evaluation. Design of the software is expected to begin in 1993, and the operational evaluation is expected to start in 1997.

AERA concepts are being introduced in project planning and development for oceanic system automation, traffic flow management, and integration of en route and terminal ATC. In more advanced AERA applications, the integration of ground-based ATC and cockpit automation will be investigated to fully exploit the potential for computer-aided interactive flight planning between controller and pilot.

5.3.3 Automatic Dependent Surveillance (ADS) and Oceanic ATC

In the ADS System, the information generated by an aircraft's onboard navigation system is automatically relayed from the aircraft, via a satellite data link, to air traffic control facilities. The automatic position reports will be displayed to the air traffic controller in nearly real time. This concept will revolutionize ATC in the large oceanic areas that are beyond the range of radar coverage. Currently oceanic air traffic control is largely manual and procedural and operates with very little, and often delayed, information. It depends upon hourly reports transmitted via High Frequency (HF) voice radio, which is subject to interference. Because of the uncertainty and infrequency of the position reports, large separations are maintained to assure safety. These large separations effectively restrict available airspace, and cause aircraft to operate on less than optimal routes.

In the ADS System the information generated by an aircraft's onboard navigation system is automatically relayed from the aircraft, via a satellite data link, to air traffic control facilities.

ADS will be a part of an Oceanic ATC System to support transoceanic flights over Pacific and Atlantic airspace.

ADS will be a part of an Oceanic ATC System to support transoceanic flights over millions of square miles of Pacific and Atlantic airspace. This Oceanic ATC system will provide an automation infrastructure including oceanic flight data processing, a computer-generated situation display, and a strategic conflict probe for alerting controllers to potential conflicts hours before they would occur. The first phase of the new system, the Oceanic Display and Planning System (ODAPS), became operational in the Oakland Air Route Traffic Control Center (ARTCC) in 1989 and in the New York ARTCC in 1992. Real-time position reporting via ADS and a limited set of direct pilot-controller data link messages will be added to the system in 1994. In 1995, a complete set of pilot-controller data link messages will be available.

The new Oceanic ATC System will provide benefits to airspace users in efficiency and capacity. The improved position reporting will allow better use of the existing separation standards. Air traffic management will be able to begin the process of reducing those standards, thereby increasing the manageable number of aircraft per route. Using the strategic conflict probe, controllers will be able to evaluate traffic situations hours into the future. Ultimately, controllers will be able to grant more fuel-efficient direct routes, which will have a significant impact on fuel costs and delays.

5.3.4. Communications, Navigation, and Surveillance

New technology enhancements in communications, navigation, and surveillance provide the basis for dramatic improvements in aviation system performance, including improved safety, reduced delay, increased capacity, and greater efficiency. These three functional areas represent key elements of the air traffic management infrastructure.

5.3.4.1 Aeronautical Data Link Communications

Data link services should relieve congestion on voice communications channels and provide controllers with an ability to handle more traffic during peak periods while providing pilots with unambiguous information and clearances. This benefit has been demonstrated during the interaction of pre-departure clearances via data link.

Data link applications are being developed based on inputs from the air traffic and aviation user communities. These applications include weather products, en route, terminal, and tower ATC communications, and other aeronautical services. The Aeronautical Telecommunications Network (ATN) allows use of many data link sub-networks (e.g., satellite, Mode S, VHF, etc.) in a way that is transparent to the users.

Domestic standards are being developed with RTCA, and the international standards, with ICAO. The en route, terminal, and tower ATC services are being developed and evaluated by a team of air traffic controllers. The operational aspects and benefits of data link applications will be verified using contractor and FAA Technical Center test beds. Pilot inputs will be gathered by connecting cockpit simulators and live aircraft to the test beds during evaluations.

5.3.4.2 Satellite Navigation

Efforts are underway to extend the Department of Defense's Global Positioning System (GPS) to provide service for civil aviation for oceanic, en route, terminal, non-precision and precision approaches, auto-landing, and airport surface navigation. Highly accurate satellite signals will provide a three-dimensional position fix. This satellite navigation technology will provide more aircraft the ability to fly direct paths instead of being confined to specific routes, and thus provide for the use of more airspace. This technology can also be used as a source for accurate position reporting without separate surveillance systems and enable reduced separation minimums resulting in increased capacity throughout the system.

Satellite navigation technology will provide more aircraft the ability to fly direct paths instead of being confined to specific routes, and thus provide for the use of more airspace. This technology can also be used as a source for accurate position reporting without separate surveillance systems and enable reduced separation minimums resulting in increased capacity throughout the system.

The goal of the satellite navigation program is to integrate GPS with the Instrument Landing System (ILS) and the Microwave Landing System (MLS) and with the Advanced Traffic Management System (ATMS). Demonstrations will be conducted on the accuracy of GPS for precision navigation. If feasible, GPS may provide a near Category I instrumented landing capability that may be sufficient at many airports.

5.3.4.3 Terminal Area Surveillance System

Although air traffic accidents may occur during any phase of flight, the largest percentage occur during takeoff and landing. Currently, there are many airports without surveillance radars, and the airport surveillance radar being procured by the FAA, the Airport Surface Detection Equipment-3 (ASDE-3), will not be available at all airports due to cost considerations. It is important, therefore, to develop affordable sensors to provide a reliable surveillance source for terminal operations and to support automation development and airport capacity initiatives.

Requirements for a new terminal area surveillance radar have been identified and include modular, cost-effective primary and secondary radar systems with application for flexible, high capacity data links, improved surveillance accuracy, improved runway monitoring, improved wind shear detection and dissemination, and improved wake vortex tracking. Efforts will focus on adapting commercial technology in order to develop a radar that meets the validated requirements in a cost-effective manner.

5.3.5 Aviation Weather

Weather is the single most important factor in delays and a major factor in aircraft accidents and incidents. Improved weather forecasts offer the potential for increasing system capacity more cost effectively than many other alternatives. Improved weather information can not only increase system capacity, but also enhance flight safety, improve flight efficiency, reduce ATC and pilot workload, improve flight planning, and result in fuel and cost savings.

Improved weather forecasts offer the potential for increasing system capacity more cost effectively than many other alternatives.

Efforts are underway to enhance our understanding and ability to predict a range of aviation weather phenomena: icing, en route and transition turbulence; ceiling and visibility; thunderstorms and microbursts; en route and terminal wind; and oceanic weather of all kinds. Models and algorithms are being developed for understanding weather and generating short-term forecasts.

To help in the understanding of weather, airborne meteorological sensors are being developed to measure humidity and turbulence. These sensors will be carried aboard aircraft to provide near-real and real-time three-dimensional weather data that is currently not available.

Wind shear is a major cause of weather-related fatalities in the air carrier community. Research is underway to develop advanced wind shear warning systems and flight crew decision aids. The technology will be transferred to manufacturers and operators to accelerate the development of these systems. Once developed, flight tests will be conducted to evaluate onboard airborne wind shear sensor performance by flying the test aircraft into wind shear. Also, a wind shear training program will be developed for air taxis, commuter operators, and general aviation.

5.4 System Planning, Integration, and Control Technology

The following sections describe technologies that support planning to integrate various improvements into the NAS. Both operational improvements and new technologies need to be evaluated so that they can be developed and implemented effectively, ensuring the interoperability of the elements of the NAS. A large number of models and other technologies will support this integration effort. The National Airspace System Performance Analysis Capability (NASPAC), for example, will help in the identification of demand/capacity imbalances in the NAS and provide a basis for evaluation of proposed solutions to such imbalances. Computer-graphics tools, such as the Sector Design Analysis Tool and the Terminal Airspace Visualization Tool, will allow airspace designers to quickly and effectively develop alternative airspace sectors and procedures. They will also reduce the time and effort required to implement these alternatives.

5.4.1 National Simulation Capability

The National Simulation Capability (NSC) will aid and support the R,E&D and systems engineering missions of the FAA by horizontally integrating the various R,E&D program elements across the National Airspace System (NAS) environment. The capability to integrate future ATC subsystems during the conceptual stage of a project will allow early validation of requirements, identification of problems, development of solutions to those problems, and demonstration of system capabilities. It will also permit early injection of human factors and system user inputs into the concept formulation process. The net result is a reduction of risk in the development of products for the NAS, faster infusion of new technology, earlier acceptance of new NAS concepts by system users, and greater efficiency in performing the R,E&D and systems engineering missions.

The National Simulation Capability will aid and support the R,E&D and systems engineering missions of the FAA by integrating various program elements across the National Airspace System environment. The capability to integrate future ATC subsystems during the conceptual stage of a project will allow early validation of requirements, identification of problems, development of solutions to those problems, and demonstration of system capabilities.

The NSC will be a unique capability that will exploit the latest simulation technology. Horizontal integration will bring together diverse system components such as terminal automation, en route automation, oceanic control, aircraft flight management systems, and mixes of aircraft types and performance in a flexible, interchangeable, and dynamic simulation environment. It will provide an ability to assess the suitability and capability of future ATC system components before production investment decisions are made. The NSC will permit the evaluation of new operational concepts, human interfaces, and failure modes in a realistic, real-time, interactive ATC environment capable of simulating new or modified systems at forecast traffic levels. Simulation capabilities will be expanded through an interface with various remote research centers that possess nationally unique facilities and expertise.

5.4.2 Analysis Tools

A large and growing repertoire of analytical, simulation, and graphical tools and models are being developed and used to help understand and improve the NAS. Some of the more prominent of these are briefly described in the following sections.

The principal objectives of computer simulation models currently in use and under development are to identify current and future problems in the NAS caused by demand/capacity imbalances and to construct and evaluate potential solutions. All of the models rely on a substantial amount of operational data to produce accurate results. The principal models that are being developed and are in use today are described below.

5.4.2.1 Airport Network Simulation Model (AIRNET)

AIRNET is a PC-based tool that is designed to assess the impact of changes in airport facilities, operations, and demand. It is a planning tool that can assess the effects of those changes on passenger costs, noise contours, airports, airlines, and aircraft. It addresses macro trends and interactions for use in policy planning and economic analysis.

AIRNET is a PC-based tool that is designed to assess the impact of changes in airport facilities, operations, and demand.

5.4.2.2 Airport and Airspace Simulation Model (SIMMOD)

SIMMOD simulates both airports and airspace in a selected geographic area. It aids in the study of en route air traffic, terminal air traffic, and ground operations. It is capable of calculating capacity and delay impacts of a variety of operating alternatives, including runway configurations, airspace routes, sectorization, and separation standards. It is a planning tool for evaluating operational alternatives involving the coordination of airport configurations with airspace configurations. SIMMOD has been used in a number of airspace design studies around major airports. Improvements to SIMMOD include better output displays, automated data-acquisition capability, and a workstation version of the model.

SIMMOD simulates both airports and airspace in a selected geographic area. It is capable of calculating capacity and delay impacts of a variety of operating alternatives.

5.4.2.3 Airfield Delay Simulation Model (ADSIM) and Runway Delay Simulation Model (RDSIM)

The Airfield Delay Simulation Model (ADSIM) calculates travel time, delay, and flow rate data to analyze components of an airport, airport operations, and operations in the adjacent airspace. It traces the movement of individual aircraft through gates, taxiways, and runways. The Runway Delay Simulation Model (RDSIM) is a sub-model of ADSIM. RDSIM limits its scope to the final approach, runway, and runway exit.

ADSIM calculates travel time, delay, and flow rate data to analyze components of an airport, airport operations, and operations in the adjacent airspace. RDSIM is a sub-model of ADSIM, limiting its scope to the final approach, runway, and runway exit.

5.4.2.4 The Airport Machine

The Airport Machine is a PC-based interactive model with graphics that is used to evaluate proposed changes to airfield and terminal configurations, schedules, and aircraft movement patterns. This model has been licensed for use within the FAA and has been used in studies of a number of major airports. Its primary output is extensive data on delays to aircraft movement.

The Airport Machine, a PC-based model, is used to evaluate proposed changes to airfield and terminal configurations, schedules, and aircraft movement patterns.

5.4.2.5 National Airspace System Performance Analysis Capability (NASPAC)

The NASPAC Project provides a long-term analysis capability to assist the FAA in developing, designing and managing the nation's airspace on a system-wide level through the application of modern tools of operations research and computer modeling. The focal point of the NASPAC Project is the NASPAC Simulation Modeling System (SMS). The NASPAC SMS is a simulation of the entire NAS that models the movement of individual aircraft as they move through the nationwide network of airports, en route sectors, routes, navigation fixes, and flow control restrictions. The model has been used to study the current and projected performance of the NAS and to study system improvements such as new airports, new runways and airspace changes as well as projected demand changes such as the creation of new air carrier hubs. The model has been improved to make it easier for analysts to use and to extend the range of applications in which it can be applied effectively.

NASPAC is a simulation of the entire NAS, modeling the movement of individual aircraft as they move through the nationwide network of airports, en route sectors, routes, navigation fixes, and flow control restrictions.

5.4.2.6 Sector Design Analysis Tool (SDAT)

The SDAT is an automated tool to be used by airspace designers at the 20 Air Route Traffic Control Centers (ARTCCs) to evaluate proposed changes in the design of airspace. This computer model allows the user to input either the current design or the proposed replacement. It also allows the user to interactively make changes to the design shown graphically on the computer screen.

SDAT is an automated tool to be used by airspace designers at the 20 ARTCCs to evaluate proposed changes in the design of airspace allowing the user to input either the current design or the proposed replacement.

The model allows the user to play recorded traffic data against either the actual design or the proposed replacement. It also allows the user to modify traffic data interactively in order to evaluate alternative designs under postulated future traffic loading. The model computes measures of workload and conflict potential for the specified sector or group of sectors. This will allow designers to obtain a better balance in workload between sectors, reducing controller workload and increasing airspace capacity. The model will also be useful for facility traffic flow managers, for it will display cumulative traffic flows under either historic or anticipated future traffic loading.

The development of the SDAT has been underway for approximately three years. Procedures for extracting and displaying (in 2D and 3D) all the requisite data from available FAA data files and computing the expected demand for separation assurance actions have been developed. The development of a fully capable controller workload model is underway. SDAT will be field tested at two selected sites in FY93.

A procedure for using the SDAT as an airspace model (assuming that controller workload is the limiting factor) is under development. This will be combined with an on-line Critical Sector Detector for traffic flow management.

5.4.2.7 Terminal Airspace Visualization Tool (TAVT)

Terminal airspace differs from en route airspace in that it tends to have a more varied mix of aircraft and user types, more complicated air traffic rules and procedures, and wider variation in flight paths. A major redesign of terminal airspace currently requires extensive coordination and the effort of a task force lasting many months or even years. The purpose of the TAVT prototype is to explore the potential for computer-based assistance to such a task force that will support a more rapid evaluation of alternatives.

The purpose of TAVT is to provide computer-based assistance in the redesign of terminal airspace.

The TAVT prototype displays a three-dimensional representation of the airspace on a large computer screen to allow the user/operator to view the airspace from any perspective. It also provides an easy-to-use interface that permits the user to modify the airspace according to permissible alternatives. The results of this effort are being evaluated for incorporation into the specifications of a follow-on terminal airspace design tool based on SDAT.

5.4.2.8 Graphical Airspace Design Environment (GRADE)

GRADE is a computer graphics tool for displaying, analyzing, and manipulating airspace design and other aviation related data. Radar data (from both ARTS and SAR) are stripped from their recording media and loaded into GRADE's underlying relational database along with the appropriate airspace geometries, terrain maps, National Airspace System (NAS) data, descriptions of routes, and any other data required in the analysis. GRADE can then be used to test proposed terminal instrument procedures (TERPS), standard terminal arrival routes (STARs) and standard instrument departures (SIDs), airspace design changes, and instrument approach procedures.

GRADE can display radar data in three dimensions, along with the attendant flight plan information, for any given time slice. GRADE also includes a set of algorithms designed to measure interactions between the radar data and any other elements of the database. These measurements can then be displayed as histograms and compared. GRADE provides a high quality, three-dimensional presentation, is relatively easy to use, and can be quickly modified to facilitate the comparison of existing and proposed airspace designs and procedures.

GRADE is currently limited to airspace design applications, but could easily be adapted to other applications, such as noise analysis, interaction with existing airport and airspace computer simulation models, accident/incident investigation (particularly for aircraft without flight data recorders), and training in lessons learned and alternate air traffic control techniques.

GRADE, a computer graphics tool for displaying, analyzing, and manipulating airspace design and other aviation related data, provides a high quality, three-dimensional presentation, is relatively easy to use, and can be quickly modified to facilitate the comparison of existing and proposed airspace designs and procedures.

5.4.3 National Control Facility (NCF)

The proposed NCF is intended to provide three major functions to support the goals of the FAA:

- The traffic management function, currently the Air Traffic Control System Command Center (ATCSCC), will ensure the viability of, and provide the national direction and airspace management of, the air traffic control system.
- The modeling and analysis function will include the data bases, personnel, and systems required to provide FAA and selected organizations with tactical recommendations and forecasts based on computer simulation and optimization models, as well as studies and analyses of the air traffic system.
- The management development function will provide a structure to familiarize users with the capabilities of the air traffic control system. Specific areas to be addressed in the curriculum include orientation to national airspace management, recurring training in system management techniques for FAA airspace managers, operational review and critique, and demonstration to the airspace system users of potential system problems identified through modeling efforts.

The proposed NCF is intended to provide a traffic management function, to provide the national direction and airspace management of the air traffic control system; modeling and analysis function to provide the FAA with tactical recommendations and forecasts; and a management development function to familiarize users with the capabilities of the air traffic control system.

This facility will house the airspace management organization, the National Weather Service Central Flow Weather Service Unit (CFWSU), the National Flight Data Center (NFDC), and the National Maintenance Coordination Complex (NMCC). The systems required to support these organizations will also be housed here.

The traffic management element of the NCF will contain the personnel and systems needed to manage the Nation's air traffic system. A proactive management role using a combination of the data currently available, improved processing, better communications, and additional data is envisioned.

The modeling and analysis element of the NCF will provide the capabilities required to perform in-depth statistical and analytical studies of the airspace system. These studies will enable the examination of solutions to airspace problems and the determination of the maximum utilization of the airspace system on a real-time basis as well as during a long-term planning effort. It will also provide simulations and reconstructions to support the training and refresher activities of the Management Development Facility. The functions required to support this effort include database management, airspace and rules simulations, and system analysis.

To support the modeling element, current capabilities such as NASPAC, AIRNET, and SIMMOD will be enhanced and used to support operational planning as well as the longer-term analysis capabilities they currently provide to support system planning of the NAS. In order to support airspace planners that will use the NCF modeling capabilities, computer-based airspace design tools will be developed. These tools will be designed to address a range of airspace design problems from relatively localized problems affecting a single sector or terminal area to regional or national scale problems.

5.4.4 Traffic Flow Planning

Increasing congestion, delays, and fuel costs require that the FAA take immediate steps to improve airspace use, decrease flight times and controller workload, and increase fuel efficiency. To achieve these objectives the FAA Traffic Flow Planning program will develop near-term, operational traffic planning models and tools. The program will provide software tools to plan daily air traffic flow, predict traffic problems and probable delay locations, assist in joint FAA-user planning and decision-making, and generate routes and corresponding traffic flow strategies which minimize time and fuel for scheduled air traffic. Benefits include improved aviation safety, airspace use, system throughput, and route flexibility. Working directly with commercial aviation interests and other FAA facilities, the Air Traffic Control System Command Center (ATCSCC) can predict problem areas before they occur and generate alternative reroutings and flow procedures. Overall system capacity will be increased over that of the present fixed route and rigid preferred route systems, and increased fuel efficiency, shorter travel times, and reduced delays will result. Controller workloads will decrease from users' participation in a planned, systematic flow of traffic.

5.5 Vertical Flight Program

The Vertical Flight Program will help improve the safety and efficiency of vertical flight operations and increase the capacity of the NAS through research, engineering, and development into air traffic rules and operational procedures, heliport/vertiport design and planning, and aircraft/aircrew certification and training.

The term vertical flight (VF) includes conventional rotorcraft (helicopters) as well as advanced technology designs for aircraft with the ability to hover and take off and land vertically, such as the tiltrotor, tiltwing, fan-in-wing, and vectored-thrust aircraft. The Rotorcraft Master Plan (RMP) envisions advanced VF technologies, such as the tiltrotor, providing scheduled short-haul passenger and cargo service for up to 10 percent of projected domestic air transportation needs. Recognizing the potential for advanced VF aircraft to provide passenger service, Public Law 102-581 requested that a Civil Tiltrotor (CTR) Development Advisory Committee be established to evaluate the technical feasibility and economic viability of developing CTR aircraft and infrastructure to support the incorporation of tiltrotor technology into the national transportation system.

VF research will be conducted in the following areas: air and ground infrastructures to permit VF operations under visual and instrument meteorological conditions en route and in the terminal area; VF operations safety; VF operations noise reduction; VF training and certification procedures; integration of maturing advanced technologies into VF operations; and analysis of the economic viability and potential benefits of CTR technology.

Air infrastructure research will focus on the ability to operate at heliports and vertiports in terminal airspace without interfering with fixed-wing traffic flow. Much of the initial work relating to emerging technologies, such as tiltrotor, will be done through simulation, to be validated with actual flight test data as the aircraft become available.

Ground infrastructure research will provide R,E&D into heliport and vertiport design and planning issues, including the terminal area facilities and ground-based support systems that will be needed to implement safe, all-weather, 24-hour flight operations. Developing obstacle avoidance capabilities is a critical design-related effort. Research will include applying lessons learned from detailed accident and rotorcraft operations analyses. Simulation will be used to collect data, analyze scenarios, and provide training to facilitate safe operations.

Aircraft/aircrew research will develop minimum performance criteria for visual scenes and motion-based simulators; evaluate state-of-the-art flight performance for cockpit design technology; and develop crew and aircraft performance standards for display and control integration requirements. Research will also be conducted to develop certification standards for both conventional and advanced technology VF aircraft.